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ABSTRACT

The research experiments on relational learning in young children contained in this report were guided by two major goals: (1) to examine the extent of conceptual transfer in preschool children, and (2) to explore the relation of both "acquisition" and "transfer" to chronological development. The performance of preschool children on several oddity tasks dealt with transfer between oddity problems in which stimulus types were Identity-Difference, Identity-Similarity, or Similarity-Difference. Based upon performance in these tasks, children were assigned to either of two groups and the relation of age to acquisition and transfer was explored, using the standard oddity presentation. A final series of five experiments were run with nursery school children investigating the possible perception of both the perceptual and numerical differences present in a standard oddity task as well as the variables controlling initial acquisition of a numerical difference problem. The data from these studies indicate that considerable cognitive evaluation is possible in preschool children. (Author/CS)

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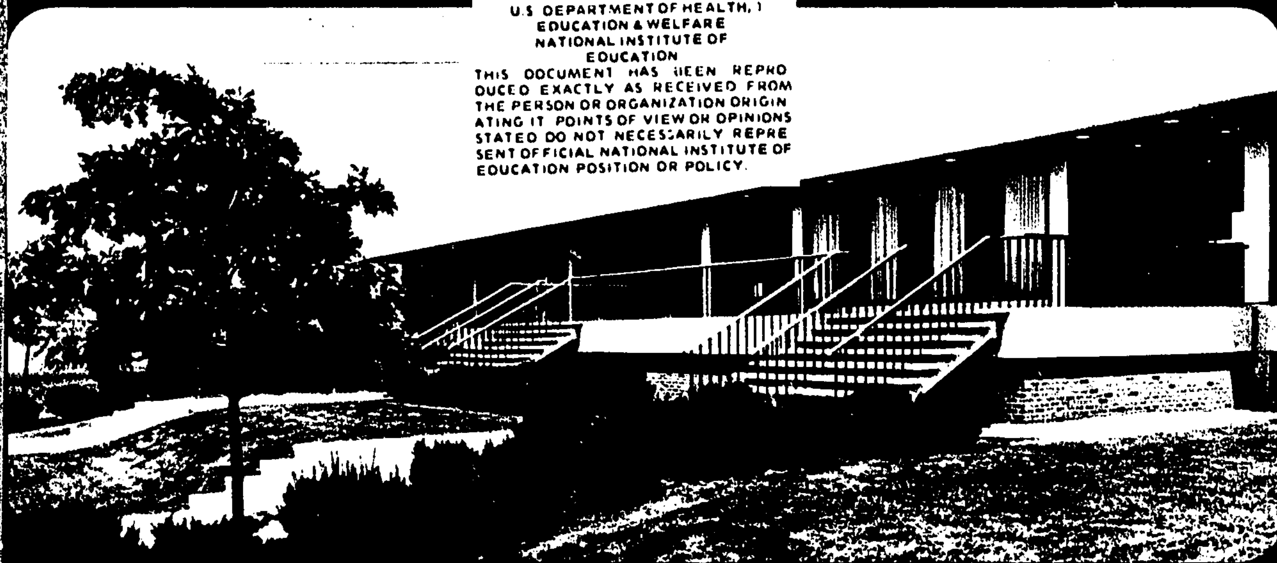

Relational learning in Young Children

Children's Research Center
University of Illinois
Urbana-Champaign

Final Report MH20195

June 1971 to May 1972

Principal Investigator, Marcia S. Scott

Acknowledgments

The following nursery schools permitted their children to participate in the experiments cited in this final report:

Busy Bee Nursery and Kindergarten School, Mr. John Bartlett, Director
Champaign Park District Preschool, Mrs. Linda [illegible], Director
Child Development Laboratory, Dr. Queenie B. Mills, Director[1]
Christian Day Care Center, Reverend Warren Swanson, Director
First Methodist Church Weekday Nursery, Mrs. Barbara Swikle, Director
Kiddie Kountry Day Care Center, Mrs. Eileen McGarvey, Director
LaPetite Academy of Champaign, Mrs. Christine Ullrich, Director[2]
Merri-Dell Nursery, Mrs. Mary K. Lerch, Director
Orchard Cooperative Nursery School, Mrs. Katherine Mutti, Director
Peter Pan Day Care Center, Mrs. Rosetta Gray, Director

I would like to thank all the staff at these nursery schools for their cooperation and assistance in the everyday running of these experiments. Without their permission, and that of the parents of the children, we would not have been able to carry out these projects. These schools have been particularly agreeable by letting us test on several occasions, for several studies. Their continued support is greatly appreciated.

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Finally, I would like to thank my husband, Dr. Keith G. Scott, for his continuous encouragement and support as well as for his critical reading of this report.

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1 Dr. Queenie B. Mills is the Head, Division of Child Development and Family Relations, University of Illinois, Urbana, Champaign.

2 At the time these studies were run the director of LaPetite Academy was Mrs. Rentschler. Mrs. Ullrich has also consented to having us there and an investigation is currently under way in which children's decision times for identification of exemplars of a simple object (dog) or a member of a category (animal) is being studied developmentally.

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Summary Statement of Progress Made Toward Achievement of Stated Aims as Presented in Research Grant MH20195

The research done with the support of grant MH20195 was guided by two major goals. These were to a) examine the extent of conceptual transfer in preschool children, and b) to explore the relation of both acquisition and transfer to chronological development.

The first aim was investigated in three different ways. One of the inquiries dealt with transfer between oddity problems in which identities were based either on perceptual matching (e.g. Mickey Mouse sitting vs. an identical picture of Mickey Mouse sitting) or character matching (e.g. Donald Duck swimming vs. Donald Duck raking leaves), and where differences were either total (e.g. a boat vs. Snow White) or partial (e.g. Bugs Bunny eating a carrot vs. Bugs Bunny looking out of a window). These stimulus types were combined into three displays using a) two identical and one different picture, b) two identical and one similar picture, or c) two similar and one different picture. These were termed Identity-Difference, Identity-Similarity, and Similarity-Difference Oddity respectively. Figure 1 presents a visual example of these three oddity problems.

Conceptual transfer was further examined within the confines of a single oddity array, but where the particular presentation (repeating vs. non-repeating pictures) and dimension carrying the oddity relationship (odd color, odd form, etc.) were shifted. The pictures used on the oddity displays were either from a total pool of three pictures, which resulted in particular pictures being used over and over, sometimes as the odd picture and sometimes as the identical pictures, or from a theoretically infinite pool, such that no picture used once was over used again. The oddity relationship was defined either with redundant dimensions (color plus size plus shape, etc.) or with a single dimension (color or form).

The relation of age to acquisition and transfer was explored in two of the studies which used the standard oddity presentation. It was found that with acquisition of the Identity-Similarity and Similarity-Difference oddity displays there was a very high failure rate associated with children from four to five years of age. Further work on acquisition of the oddity variations was indicated before a successful comparison with younger children could be made. However, pilot data was gathered on three-year-olds performance on the I-S and S-D problems after acquisition on the standard I-D oddity display. Even using the standard problem as the initial criterion problem, however, there was a considerable failure rate associated with the initially presented problem. Performance was not considered across several developmental levels on the numerical oddity problems either. These were primarily exploratory studies to track down the critical control variables on a single age group with attempts to explore developmental trends left until later. Some developmental data will be gathered imminently since the end of the series of small studies resulted in a successful manipulation of a numerical oddity display. That is, acquisition of a number oddity problem (defined as two vs. two vs. one) was met by all children in one particular group. We expect to use this display as the basis for examining transfer from a standard array to this numerical array, and to examine transfer from this simple restrictive numerical array to a broader relational number oddity problem where there are any

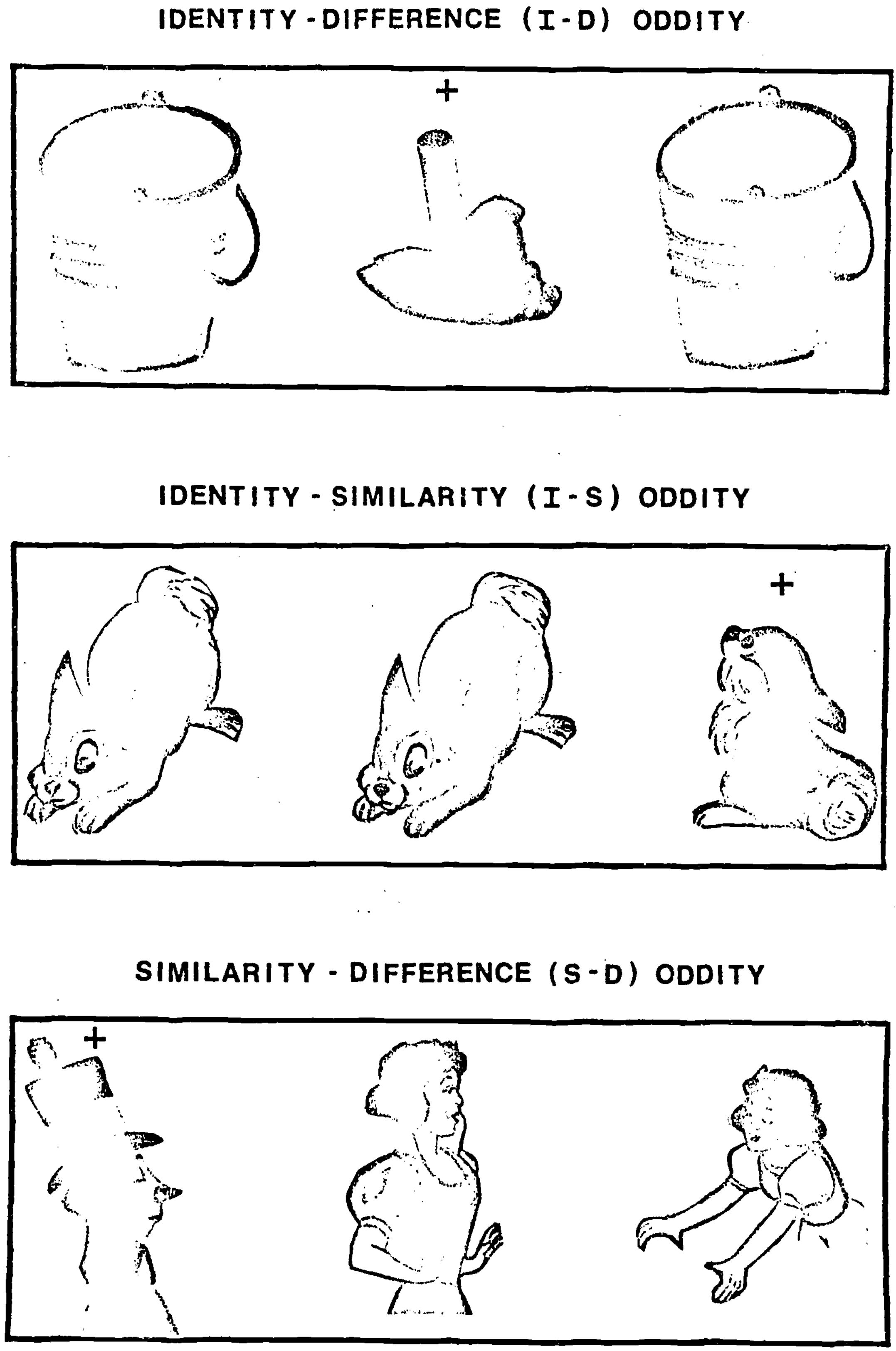

Figure 1. Pictorial examples of the three oddity variations.

combination of number of instances, e.g. two vs. four vs. four; six vs. six vs. three; five vs. six vs. five, etc. Here the number of instances in two groups are identical and different from the third. The relation of initial acquisition and bredth of transfer will then be considered as a function of chronological age.

Finally an attempt was made to examine conceptual transfer between perceptual oddity and an oddity problem in which the solution is based on numerical groupings. The initial question asked if children were aware that in a standard Identity-Difference problem, the winner is both perceptually different from the other two pictures <u>and</u> the <u>single instance</u> of a picture. This question led to initial attempts at transfer to numerical oddity problems and also to a series of studies attempting to discover the variables controlling acquisition of a numerical oddity array. It became evident that unless a numerical array were devised which could be learned by a control group, it would not be possible to get a good test of transfer to a numerical oddity problem from the standard perceptual oddity array. That is, if the numerical array were presented more favorably then it would become evident, by their continued perfect performance, that young children did have this multi-attribute solution of a standard oddity problem. Given a numerical oddity problem which could be learned easily, then the presence or absence of this numerical attribute could be fairly assessed.

Where possible chronological age has been included as a factor. The exceptions are where technical problems, such as high failure rates, preclude a meaningful developmental study.

Some current theories posit very limited cognition or mediated behavior in young children. The present data and other research by the investigator shows that children under four years are capable of complex mediated behavior. The interesting question is how this behavior develops and most immediately for the extension of the present experiments to examine possible developmental trends in bredth of transfer. A prerequisite to such an investigation is a training technique which will increase the number of three- and four-year-olds who can acquire the basic oddity concept. While some studies found a high degree of learning in four-year-olds (Scott, 1973), the samples in some of the studies reported here did not have a high learning rate. More efficient and reliable oddity training is needed to get a sufficiently large number of children on the initial task. Only then can meaningful data on bredth of transfer be obtained.

Summary of Designs and Experimental Results

Acquisition and transfer between I-D, I-S and S-D Oddity

Fifty-four children were randomly assigned to one of three groups. Each group of 18 children was presented one of the three types of oddity problems as initial tasks. After learning the problem, or failing to do so, the children were assigned to one of the two remaining oddity problems for transfer performance to be assessed. An attempt was made to balance the assignment of learners and failure children. All the children were four years of age or a few months over.

Results

1. The standard Identity-Difference (I-D) problem was learned more easily than either Identity-Similarity (I-S) or Similarity-Difference (S-D) Oddity in terms of errors and trials to criterion. The I-S and S-D problems did not differ significantly.

2. These differences seem to be primarily due to the different number of children who learn. When a comparison of the three oddity types was made considering only the children who did learn (still in terms of errors or trials to criterion), group differences were no longer present in the data. Only 2/18 children failed the I-D problem, 7/18 failed the I-S problem and 11/18 failed the S-D problem.

3. Since there was some difference between the two oddity variations in terms of number of failures, even though these differences were not significant with this sample of children, it seems possible that these two oddity variations could, with a different sample of children, prove to be realiably different. Several comparisons would lead to more stable estimates.

4. Considering only the learners of the original problems and their performance on the transfer problems, both I-D and I-S oddity problems were learned significantly more rapidly as transfer problems following previous learning of one of the other oddity displays. The S-D oddity problem was not learned more rapidly as a transfer problem.

5. The absolute performance on the transfer tasks of the children who learned the original problems was very high for the I-D and I-S oddity types. The mean errors made by the eight children transferring to the I-D problem from the I-S or S-D oddity set was .12. Similarly, of the 12 children transferring to the I-S display from the I-D and S-D problems, only one child failed to maintain near perfect performance, with the remaining 11 children having made only .82 mean errors. This suggests that there is considerable flexibility in the use and application of one oddity rule to varying situations, even with four-year-old children. Transfer performance to the S-D problem was poor. Three out of fourteen failed it completely, three made more than 10 errors before learning the task, and only five made no errors on the transfer problem.

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Although these data would suggest a deficiency in transferring to this relational difference problem (pick the most different picture) it is inconsistent with previous results and also with a subsequent group run after this. In another sample of children who were presented the S-D problem after learning a standard I-D problem six of seven made 0 or 1 error on transfer while one child, who learned the original problem late when the set was repeating, did not transfer. Consequently I feel that the estimate of transfer to the S-D problem made from the data in the larger study, is probably not valid. A replication, where more learners are obtained on the original tasks is necessary.

Given the high failure rate associated with the two oddity variations with four-year-olds, it was felt that any comparative studies between age groups would have to be limited to transfer from the simple I-D problem to the other two variations. Pilot data was obtained from three-year-olds who were first taught an I-D problem and subsequently either the I-S or S-D oddity display was present for 12 trials. The limited data suggest that transfer to these variations of the perceptual array is less than that found for transfer involving dimensional changes where the particular oddity display is not changed (e.g. I-D color to I-D form). These pilot data will be followed up by an experiment in which three-, four-, and five-year old children will be given a standard I-D oddity problem and then transfer will be assessed on either the I-S or S-D oddity problem.

Summary

One of the concerns generating this investigation was whether or not transfer to related oddity displays could be performed by naive preschool children. It can be concluded that such transfer is possible. Broad and immediate transfer was found from all oddity displays to the I-D and I-S oddity problems. Transfer to the S-D oddity task was inconsistent across studies. One follow-up sample did demonstrate excellent transfer to this task also indicating a broad degree of transfer. Such flexibility must imply a more sophisticated cognitive development than would be characterized by such descriptions as 'simple associative' or 'automatic without cognitive intervention'. It is also clear that oddity relationships which are not successfully acquired when presented as original problems can be solved once the children's perceptual apparatus is directed towards searching for similarities or identities and differences. Indeed, transfer is so immediate that the application of the previously learned rule can occur without the necessity for any feedback regarding accuracy.

Transfer between dimensions and type of presentation in a standard I-D oddity problem

Experiment 1

Experiment 1 taught a simple I-D oddity problem using non repeating pictures (no picture used on one stimulus card was ever repeated on another card) to three-, four-, and five-year-old children. The stimuli were meaningful pictures cut out from children's books. The problem was presented to a criterion of 9 consecutive correct responses or for a total of 30 trials. Following acquisition, the children who learned were shown 18 I-D oddity cards which were made up from a pool of only three different pictures. Thus over trials the same pictures reappeared, sometimes as the correct odd picture and sometimes as the incorrect matching stimuli. A control group of children was only shown the 18 card repeating picture condition.

Results

1. Considering all the children who entered the I-D problem, there was a significant effect of age, with the four and five-year-olds (mean errors = 4.0 and 4.1 respectively) learning the task more easily that the three-year-olds (mean errors = 11.0). Since only five threes learned the task, with one of these having a high errors to criterion score, while the other four learned fairly rapidly, there was no comparison of learners only. The wide range and few learners does not afford a stable estimate of three-year-olds performance on this task.

2. The percentage of children learning the task was consistent with the previous findings. There were 87% (13/15) of the fours, 90% (9/10) of the fives and only 33% (5/15) of the threes who learned the problem.

3. When the children's performance on the first 18 trials of the standard I-D oddity problem, was compared to the performance of the children on the 18 trial control condition where the pictures were repeating, it was evident that on both problems, the threes were performing below the level of the four- and five-year-olds who were similar, but there were no other main effects or inter-actions. The repeating pictures condition did not prove to be noticeably more difficult than the standard condition. Having the same pictures reappear over trials as both correct (odd) and incorrect (non odd) cues, which set the stage for possible specific stimulus interference, did not result in any noticeable increase in errors.

4. When trial 2 performance in the repeating pictures condition was examined where the previous positive and negative pictures were reversed, the number of correct and incorrect choices made at each age level in the two oddity presentations, did not differ significantly. The largest difference was found for the threes but even this was only marginal ($p<.10$) and only children who were not responding relationally were considered. That is, the data from any child who made no errors, or who made only one error on the first trial was not considered. This removed from consideration all children who had discovered the relational solution before their selection on trial two. There was thus no evidence for greater errors due to specific stimulus tracking interference in the repeating pictures condition.

5. Consideration was then given to the performance on the transfer task of the learners of the original problem. When only the learners of the first problem were considered, there was no longer any significant effect due to age. The mean percentage correct responses for the threes, fours and fives on the 18 transfer trials was 92, 95 and 98.

6. The transfer was immediate. Of the 27 children who learned the original problem, 25 made no more than 1 error and this was not on the first trial. Thus, the transfer was not simply easier learning but rather an application to the new situation before any further feedback had occurred.

7. Performance on the first six trials of the repeating pictures condition for the transferring children was significantly better than that of the control children on their last six trials. This comparison adjusted for total oddity trials.

Experiment II

In experiment II transfer from one type of presentation e.g. repeating pictures, to another type of presentation, e.g. non-repeating pictures, was again examined but with an increase in the number of possible trials and transfer assessed in both directions. The increase in trials was to see if perhaps differences between the two types of presentations might become apparent with a series longer than the 18 trials on which a comparison was based in the first experiment. Also, the dimension on which the oddity relationship was represented was also varied. Thus the odd picture could either have a single relevant dimension i.e. odd color, odd form, with the other dimension constant within and between trials, or several dimensions could be relevant i.e. odd pictures, all aspects present and different being relevant. Only three- and four-year-olds were included since the biggest difference in Experiment I seemed to be between these two age groups.

The children were shown either a non-repeating pictures presentation with cartoon (multi-dimensions relevant) pictures as stimuli until a criterion of nine consecutive correct responses had been met or until 36 trials had elapsed or they were shown cartoon, color or geometric form stimuli in a repeating pictures presentation to the same criteria or cut off. Following presentation of these first problems, the children from the repeating pictures presentation (10 from each stimulus type group) were subsequently presented the cartoon stimuli in the non-repeating condition, and the 30 children given the non-repeating condition were divided among the three types of stimulus types (10 to a group) and given this repeating pictures presentation. An attempt was made to balance for number of learners and failures assigned to the different conditions of transfer.

Results

1. Considering all the children who entered the original problem, and considering both presentation types as first problem, there was again a significant effect of age. This resulted from the superior performance of the four-year-olds (mean errors = 7.9) as compared to the three-year-old children (mean errors = 15.2) on both presentation types as was found in Experiment I.

2. Considering all children, there was again no effect of presentation type. The appearance of a specific stimulus as an odd cue on some trials, and a non odd cue on other trials, did not lead to inferior performance.

3. When only learners were considered, the fours were still significantly superior to the threes and there was still no difference between types of presentation.

4. There was a greater percentage of failure Ss in the repeating pictures condition but this difference was only significant when the two age groups were combined. Considered separately, the largest effect was found with the three-year-olds but the pass-fail difference between presentation types was still only marginal.

5. As in Experiment I, an examination of possible performance differences on trial 2 in the two types of presentation revealed no large increment in errors associated with the specific cues reversal in the repeating pictures condition. The largest difference was again associated with the younger children, but again only a marginal level of significance was attained. Given that data from all children who made no errors or only first trial errors was excluded, this provides strong evidence that there is not greater specific stimulus interference associated with the repeating picture condition.

6. The three-year-old children showed a significantly inferior performance level compared to the four-year-olds, considering only the repeating pictures condition as an original problem, and adding stimulus type (cartoon, color, or form stimuli) as a variable of interest.

7. Although there were no effects solely related to type of stimulus used in the repeating picture condition, a marginal interaction between Age and Stimulus type was observed. The mean errors to criterion for the three- and four-year-olds on the three stimulus types were:

	Cartoon	Color	Form
3	14.8	19.3	14.4
4	7.1	6.4	14.4

The fours had difficulty with the geometric form stimuli while the color oddity problem was most difficult for the three-year-olds.

8. Only a small number of three's learned the repeating picture condition. A learners only comparison was made solely with the four-year-olds. Consistant with the stimulus effects observed in the interaction just mentioned where all Ss were considered, there was a significantly higher mean errors to criterion (5.0) associated with the form condition. Comparable means for the cartoon and color conditions were only .86 and 1.14 respectively. Although the mean for form is based on only four measures, the scores are fairly homogeneous (i.e. 5, 1, 7, 7) and the trend is the same as that found with all children considered.

9. Considering the performance of the children who had learned the first problem, when they were given the transfer problem, there were no significant differences between type of presentation. As in acquisition, performance on the repeating picture transfer presentation was no different than that observed for the non repeating picture transfer condition. The dependent measure here was number of correct responses out of six on the first two six trial blocks. Since performance was nearly perfect for most children, criterion of 9 consecutive correct was met almost immediately and there are little data from trial passed the first 12.

10. Unlike the results of experiment I, there was still a significant difference between the three- and four-year-olds on the transfer problem. The mean number of correct responses out of 6 for the fours was 5.8 and this same score for the threes was 5.3. The means for these two age groups on the two types of presentation were practically identical.

11. When stimulus type did not change (cartoon to cartoon) the data do replicate similar conditions of experiment I. The mean errors made on the first nine trials by the fours when transferring between presentation types but within stimulus type (cartoon to cartoon) was 0.0 regardless of direction of the change. The three's had few learners but when these transferred they averaged 1.0 errors (N=3) going to the repeating pictures and .33 (N=3) going to the standard non repeating picture condition. Again although these are based on a very small N, the scores were homogeneous. As is evident, there seems to be little difference between the two age groups.

12. Although transfer was generally good going from non-repeating cartoons to repeating color or form problems, the four-year-old group had 1/23 children fail. This child was in the form group. The three-year-olds had 3/13 children fail the transfer problem and all three were in the color group. Thus, although there are not a large number of poor performers on transfer, the difficulty observed for the two age groups was seen in the particular conditions which were also most difficult as original learning problems.

13. Transfer of the fours from repeating pictures to the non-repeating cartoon presentation was very good. One child failed to transfer and he originally learned the geometric form oddity problem. None of the seven threes who learned the first task failed to transfer to the non repeating cartoon pictures.

14. Transfer performance on the repeating pictures condition of children who had originally learned the nonrepeating pictures/cartoon stimuli oddity problem and who transferred successfully. Given is the mean errors to criterion.

	Cartoon	Color	Geometric Form	Number Transferring
3s	1.0 (N=3)	0.0 (N=4)	1.0 (N=3)	10/13
4s	0.0 (N=8)	0.0 (N=7)	0.3 (N=7)	22/23

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15. Transfer performance on the non-repeating picture/cartoon stimuli oddity problem by the children who first learned one of the repeating pictures conditions and then transferred successively. Given is the mean errors to criterion. The scores are grouped according to the stimulus type previously learned.

	Cartoon	Color	Geometric Form	Number Transferring
3s	0.33 (N=3)	0.0 (N=1)	3.0 (N=3)	7/7
4s	0.0 (N=7)	0.4 (N=7)	0.3 (N=3)	17/18

Summary

These data clearly do not support the idea that repeating specific stimuli as odd and non odd cues results in interference in young children's oddity performance. There was however, one highly relevant condition present in both these studies which may be the controlling factor. In both experiments before the children were presented the repeating picture condition, they were warned that particular pictures would reappear and sometimes these would be the winner and sometimes they would not. Such preknowledge was not provided in the older oddity studies. A follow-up experiment in which this prewarning is either given or not given would clear up the possibility of whether or not this variable plays an important role in the presence or absence of interference effects from having identical pictures appearing as both types of relational cues. Such an experiment is planned. If it turns out that a simple warning is sufficient to eliminate specific interference, then this factor (specific stimuli interference) should be relegated to a less important role in explaining cognitive development.

In addition it is clear that when there is a minimal amount of change (presentation only) age effects present in acquisition are absent in transfer. When these are combined with stimulus change, then there are still some differences present in the transfer of three- and four-year-old children. Although there were some children who failed to transfer in the three-year-old group, it is still rather impressive to note the number of three-year-olds who were able to transfer across both presentation and stimulus changes. Certainly sufficient transfer was shown even by the three-year-olds to support the idea that these younger children can hold a relational solution and transfer to different situations well.

Children's detection of perceptual and numerical groups in terms of identities and differences: Some initial studies

Since young children will often describe their solution of a standard I-D problem in terms of the twoness of the identical pictures i.e. "There's two of them" the question was raised as to whether they truly have a grasp of both the perceptual differences between the identical pictures and the different picture, and the numerical differences, namely there are two instances of the incorrect cue and only a single instance of the correct cue. Restated, the odd picture is both perceptually different and numerically different; there is only one of it and it is different from the other pictures. Are young children aware of this dual attribute after they have successfully performed on this simple oddity task?

Experiment I

The first study examined acquisition of a standard oddity problem (using 12 x 18 inch cards) followed by transfer to a number oddity problem (12 x 18 inch cards) which displayed two of one picture, two of another/picture and one of a third picture. The individual pictures were spread over the entire card (see Figure 2). Another group of children were first given the number oddity problem and then the standard oddity problem.

Results

1. As first problems, the standard I-D oddity task was significantly easier than the number oddity set. This result was considering all children who started the task.

2. The number of learners in the two oddity types was 9/15 in the standard task and only 4/15 on the number oddity set. Since the range of scores of the four learners in the number task was large (0, 1, 13, 13) the sample is considered too small to make any estimates of expected errors to criterion for children learning this task.

3. Of the nine children who learned the standard oddity problem, seven of them transferred to the number oddity presentation. The mean errors on the first nine trials (criterion was nine consecutive correct responses) was only .43 for these seven children.

4. The four children who learned the number oddity task as the first problem all transferred perfectly to the standard oddity presentation. No errors were made on transfer.

Experiment II

The first experiment was encouraging but it was possible that the children had been using a perceptual solution on the number transfer task. After-the-fact it was decided that they might have been mentally grouping one set of identical pictures and comparing them to the single different picture and then doing the same thing for the other two identical picture. That is,

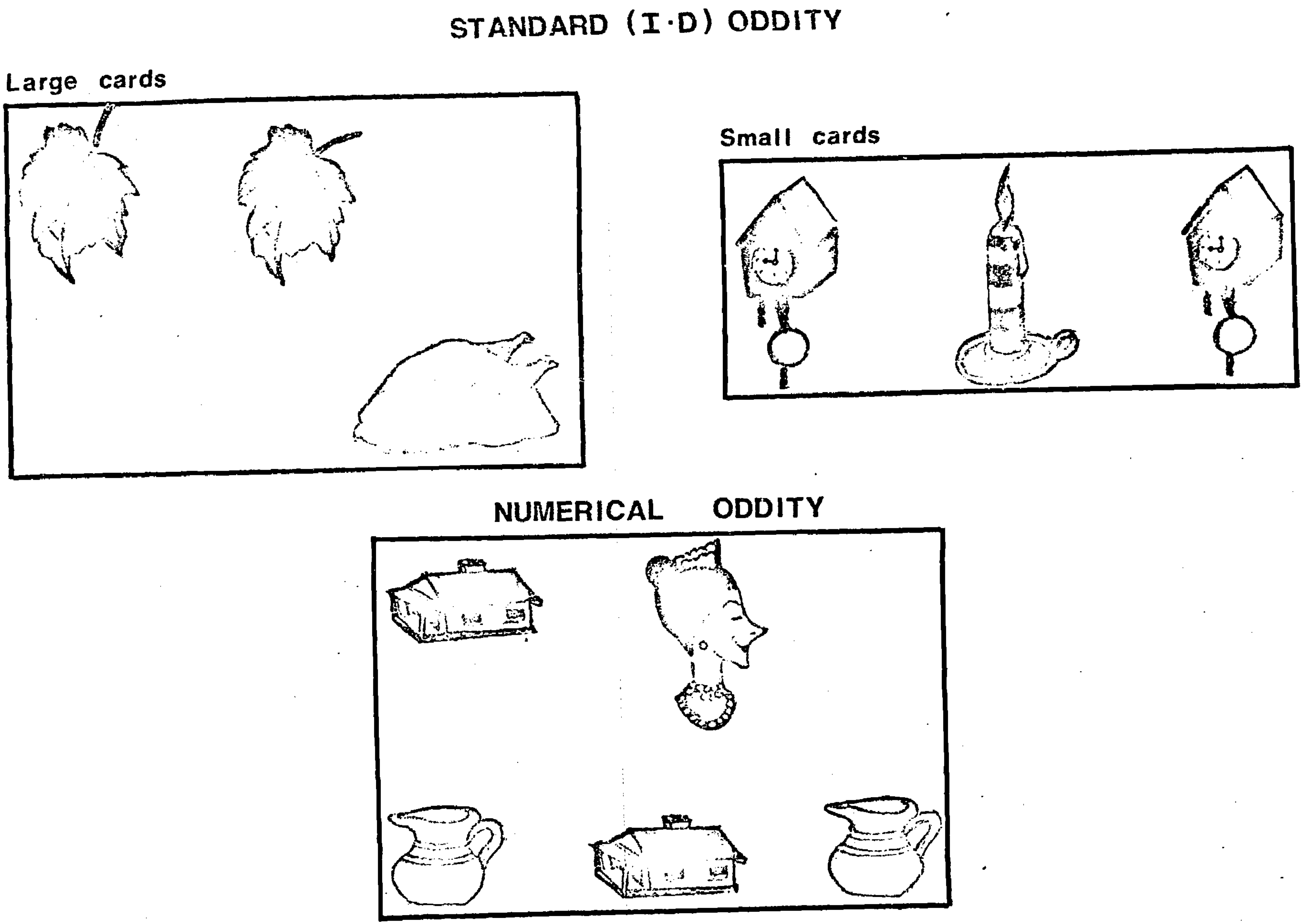


Figure 2. An example of the standard (I-D) oddity problem on large (12 x 18 inch) and small (7 x 18 inch) cards, and the first numerical oddity presentation large (12 x 18 inch) cards.

they might have looked at the cards and thought something like "this picture (cow) is different than those two (hats) and it is also different than these two (trees) so this (cow) is the winner now." In the second experiment we set up essentially similar groups but used a number oddity presentation where there was no possibility for a perceptual solution. A set of number oddity cards was made up which used different pictures on each card, while in addition, each card had five different pictures grouped into sets of two, two, and one (see Figure 3). One group of children were given 30 trials of standard oddity followed by 12 trials on a set of number oddity cards. The other group of children were given 30 trials on a set of number oddity cards followed by the same 12 number oddity transfer cards shown to the other group. In addition, the standard task was taught on the more commonly used 7 x 18 inch cards which present the three pictures in a horizontal array. It seemed that there were more children who failed the standard task in the last experiment than was expected. It was, therefore, deemed appropriate to go back to the more commonly used size and presentation in order to optimize the presentations for learning. At the end of the first 30 cards both groups of children were told they had played very well and now the game was going to be played with this other set of cards. No other explanation was offered. Children at a local nursery school who had not participated in one of the other oddity experiments were assigned to one of the two groups. By the time there had been seven children run in each of the groups, it was evident that no further children needed to be run (see Figure 4).

Results

(No statistical analyses as yet)

1. Six of the seven children learned the standard oddity problem within the thirty trial limit while none of the children in the number problem learned the task within the same number of trials.

2. When the 12 transfer trials were presented, there was no evidence that the children had any notion of "oneness" or "singleness". Their performance fell to a level comparable to the number group who had not solved the problem by this time.

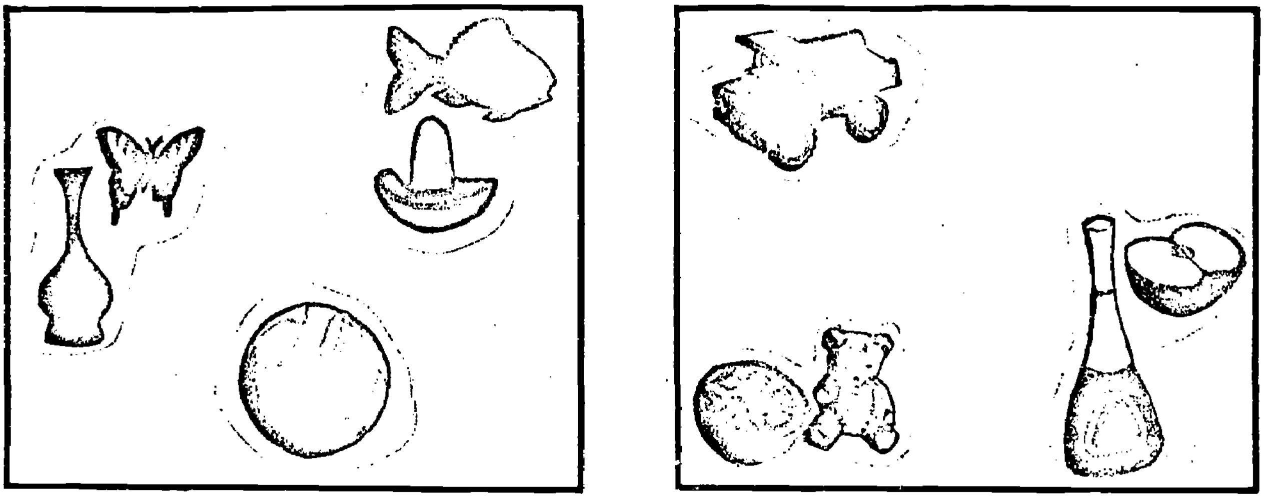
3. One of the six children transferring from standard oddity did learn the number problem after an initial three errors.

Although the pictures had been cut or pasted together in an effort to facilitate the numerical groupings of these discrepant objects (groupings of two on a common white background (see Figure 3) the transfer, or lack of it, indicated that the children did not go into those transfer trials with any notion about the numerical qualities of the single/different winner in the previous game.

Since these transfer data were inconsistent with the few verbalizations given by the children in the initial transfer study, further experiments were run before ruling out the possibility of a multi-attribute solution of the perceptual oddity task.

NUMERICAL ODDITY DISPLAYS

ALL DIFFERENT PICTURES



All IDENTICAL PICTURES

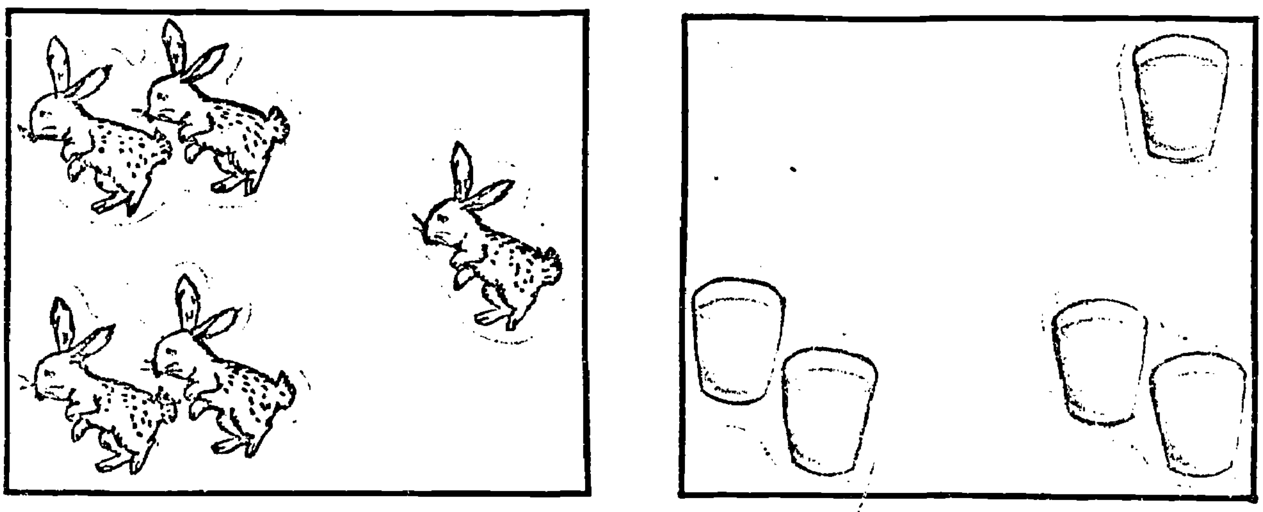


Figure 3. Examples of the numerical oddity displays using different or identical pictures.

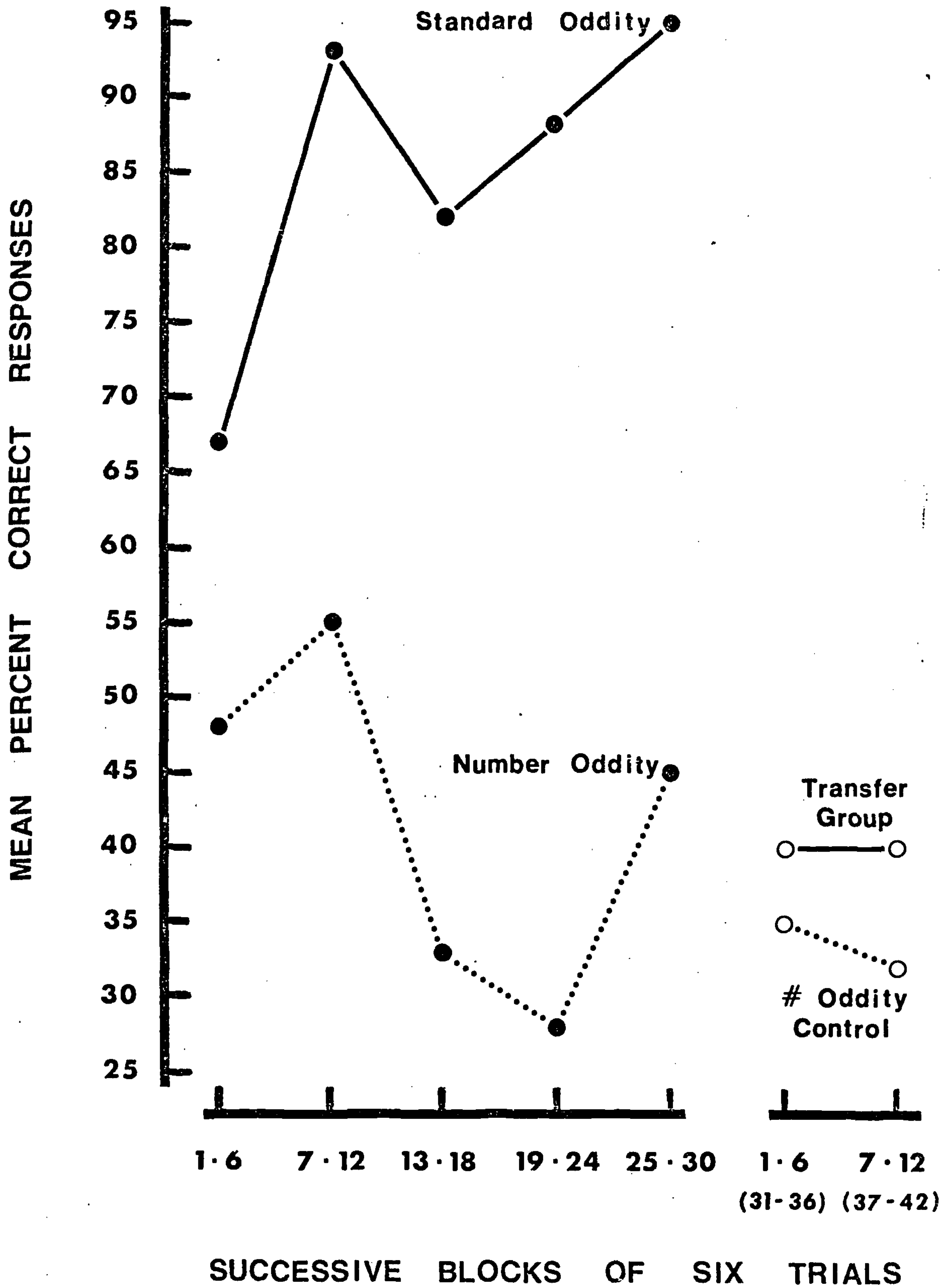


Figure 4. Performance of the control group on 42 successive trials of number oddity; and the transfer group on 30 successive trials of standard oddity followed by 12 trials of number oddity.

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Experiment III

The next experiment considered possible decremental effects of switching from the small (7 x 18) cards where the array is always presented in a horizontal display, to the number oddity presentations on large cards (12 x 18) where the stimuli are spaced over a larger area and different scanning strategies might be employed (see Figures 2 and 3). On the initial experiment where some transfer was observed, there had been no change in the size of the cards. Another two groups of four-year-olds were run. As before, one group was given 30 number oddity trials on large 12 x 18 cards followed by 12 trials on an additional set of large number oddity cards. The group given training first on standard oddity, learned the problem on the small 7 x 18 inch cards, but then transferred to a regular oddity problem on the large 12 x 18 inch cards and only after meeting criterion on this problem were the 12 number oddity trials given on the large cards. Thus, if there were any scanning strategies which detrimentally effected the possibility of showing transfer, these would no longer be present. Strategies of scanning the pictures would have been switched on the second standard oddity problem.

Results
(No statistical analyses yet)

1. Only one of thirteen children learned the number oddity sets within 30 trials. Twelve of the fourteen children started on standard oddity learned the problem within the first 30 trials. The remaining two learned the problem during the presentation of the large standard oddity cards so that 14/14 children learned the first standard oddity problem before entering the number transfer trials.

2. Only four of fourteen children learned the transfer problem. These four made 0, 2, 4, and 6 errors to criterion.

It seemed that even when the possibility of negative scanning strategies was accounted for there was still no large evidence of a multi-attribute solution of the standard oddity problem. Four out of 14 is not a very large hit rate, nor was the number of errors made by the four learners very encouraging.

Experiment IV

This experiment was concerned with the absolute size of the cards used. Perhaps when the stimuli are spaced apart as they must be on the large cards (see Figure 2 or 3) the presentation is so poor for making relational groupings that a numerical cue learned on the initial standard task is just not perceived on the transfer trials, and so not applied. Since no children to speak of were learning this numerical oddity problem even when it was presented for as many trials as the standard problem (control group) it indicated that the display might be a poor one for making such comparisons among the stimuli as are necessary in order to become aware of the relationships present. Before trying to assess transfer, a numerical display which four-year-olds could learn as an initial problem was needed. The next experiment in the series presented the number oddity sets on 7 x 18 inch cards, where all comparisons are across a horizontal array, and presented the standard oddity presentation on large cards (see Figure 5). There were 10 children in each group and each oddity type was presented for 30 trials. The number display still used five different pictures on each card grouped into sets of two, two, and one.

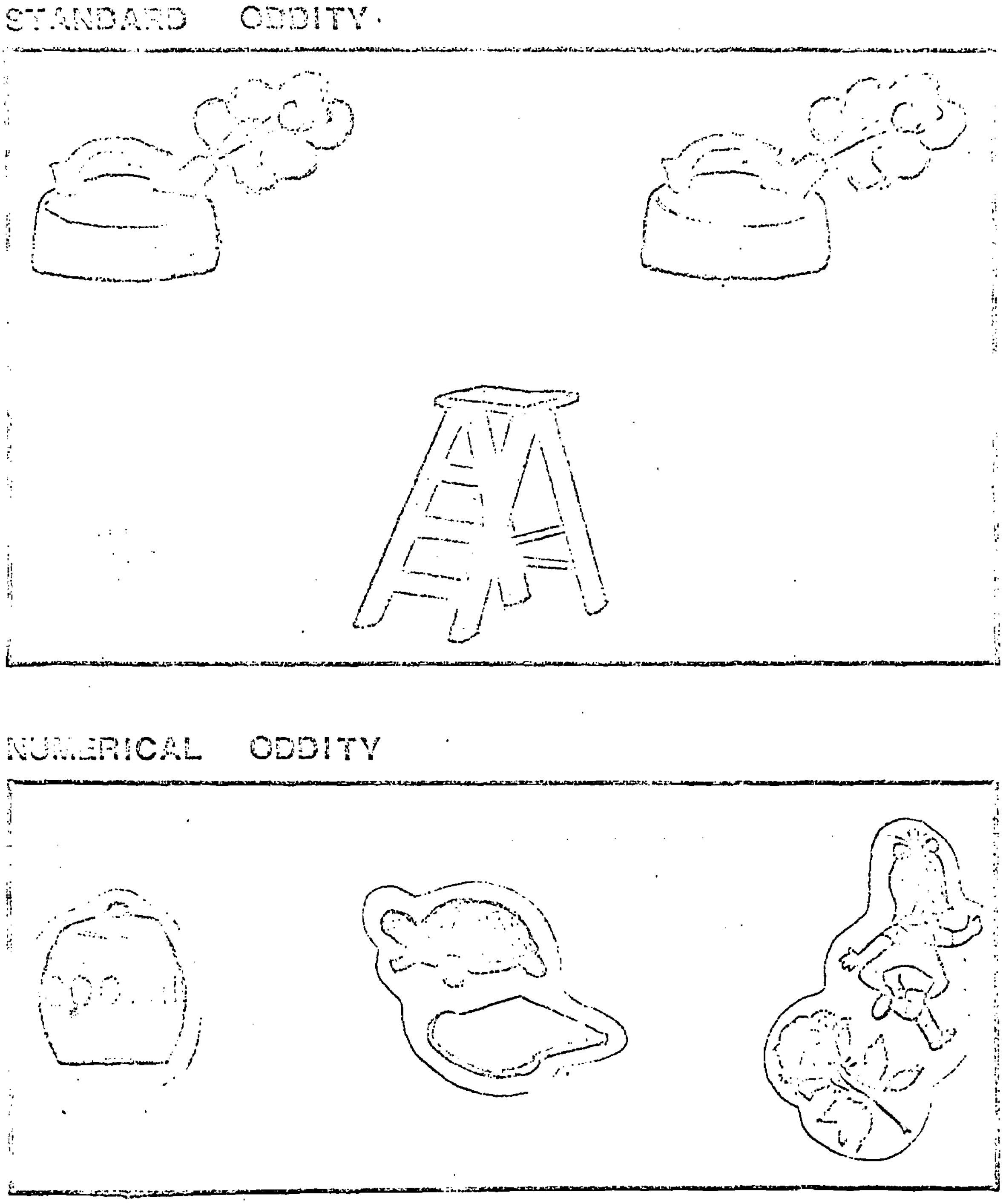

Figure 5. Examples of the standard oddity display on large (12 x 18 inch) cards and the number oddity display on small (7 x 13 inch) cards.

Results

1. Eight of ten children learned the standard oddity problem on large cards where multiple scans of varied direction are probably necessary and only two of ten children learned the number oddity problem presented on the presumably favorable display where only horizontal scans are required. These data were combined with previous results of standard oddity on small cards and number oddity acquisition on large cards and the four groups are presented in Figure 6. Obviously the size of the cards, as this might relate to perceptual comparisons and the discovery of relationships among the stimuli, is not the critical variable controlling acquisition of these two oddity types.

Experiment V

The final study completed during the active life of this grant examined one more variable which might be effecting the acquisition of the number oddity task. Since children probably have had little experience with numerical groupings per se, but a lot of experience naming and using objects, the degree to which object variation was present as a possible solution might well control the ease with which the numerical relationship would be perceived. Therefore, an additional two groups of children were run on a numerical oddity problem in which on any one card, all the pictures were identical, but they were grouped again into two pairs and one single (see Figure 3). As before one oddity set used big cards (12 x 18) and one used small cards (7 x 18). Each number oddity type was presented for 30 trials.

Results
(No statistical analysis yet performed)

1. Having the same objects on each card greatly reduced the difficulty of the number oddity problem (see Figure 7). With the big cards, 9/14 learned the task and on small cards 9/13 learned the problem. Criterion was considered to have been met if the children made nine consecutive correct first responses.

Removing the variation in the objects present on the card made the numerical groupings more apparent to the child, although performance was still not as good as that seen for children given a standard oddity problem.

Another experiment was run which, although executed after the end of the time of this grant, was based entirely on the data obtained from these studies. In that experiment, as one of the groups, a numerical oddity problem was used in which all the objects on a given card were identical, they were grouped on small cards (7 x 18) into two, two and one, and furthermore, the three groupings were separated by white lines to further enhance the numerical groupings (see Figure 8). When this was done, all of the ten children started on the task learned it. Most with only a few errors. This presentation will be used as a transfer problem to come after a standard oddity problem. Here is a presentation in which the numerical relationship is salient to children. After performance on a standard oddity problem, children will be given trials on this number display. Whatever the outcome, it

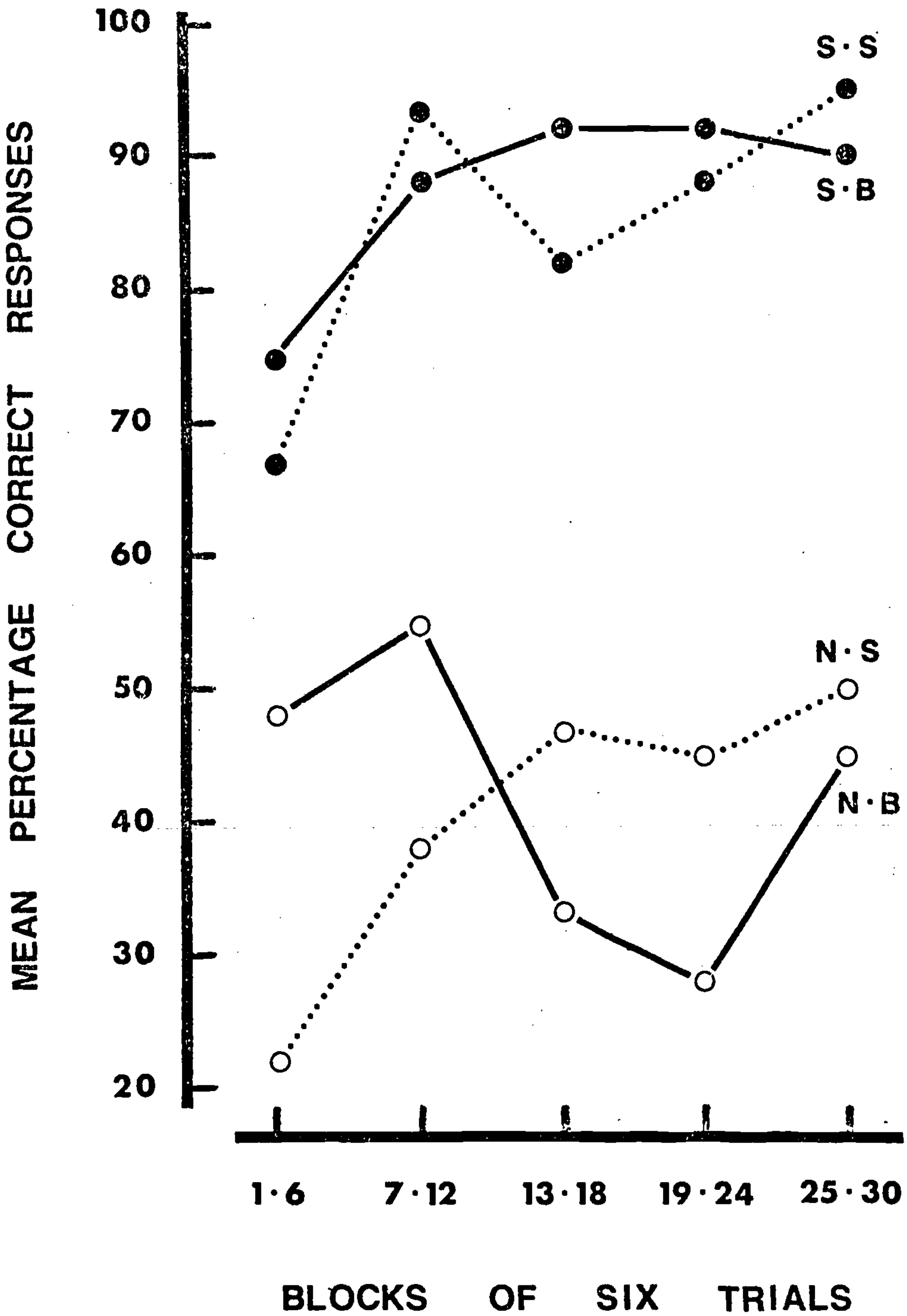

Figure 6. Performance of the standard oddity groups (S) and the numerical oddity groups (N) on big (B) and small (S) stimulus cards.

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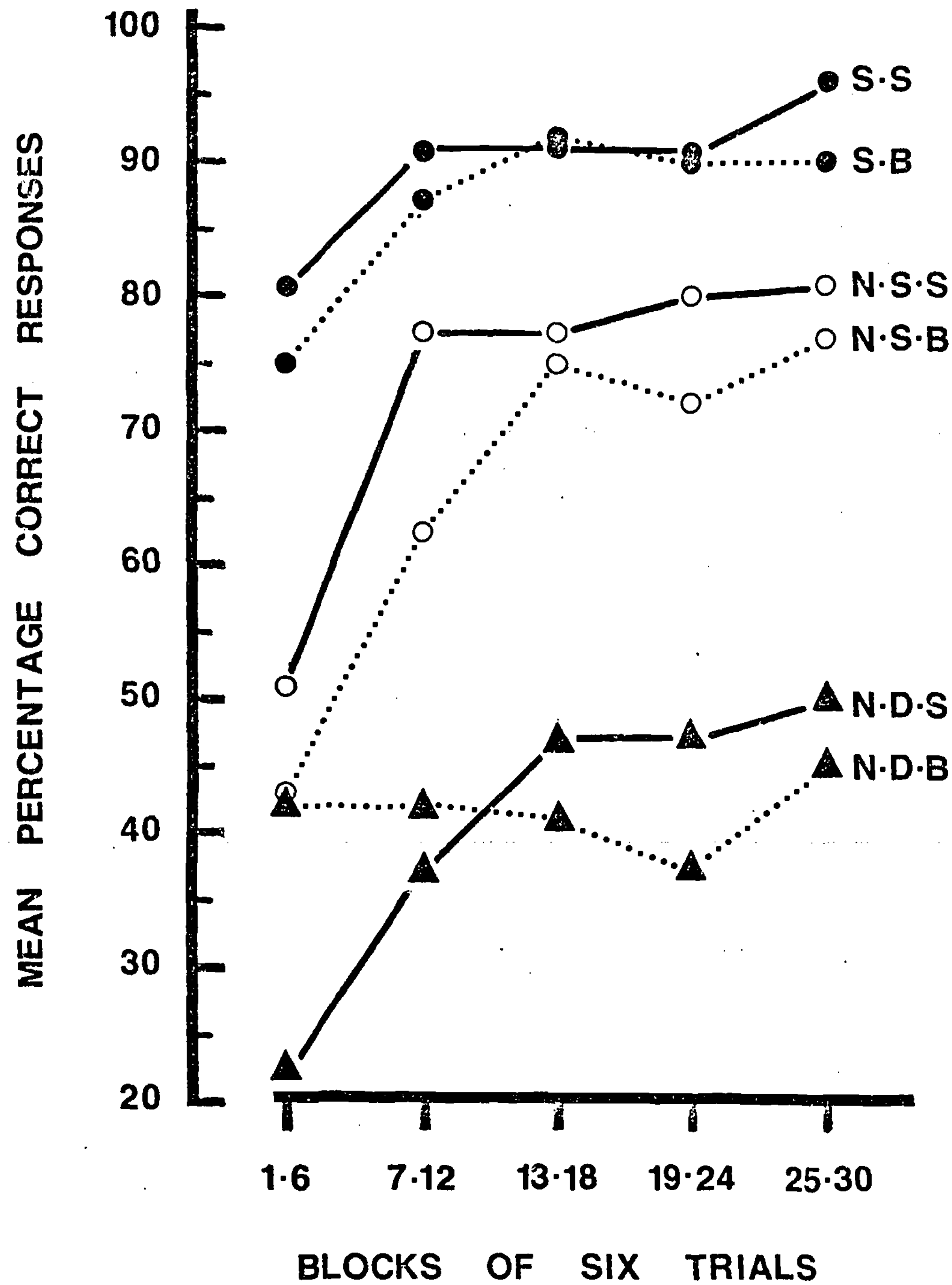

Figure 7. Performance on the numerical (N) oddity problem with all pictures on a card the same (S) or all different (D) on either small (S) or big (B) stimulus cards. Also shown is the performance of children on the standard (S) oddity task on either small (S) or big (B) stimulus cards.

FINAL NUMBER ODDITY DISPLAY

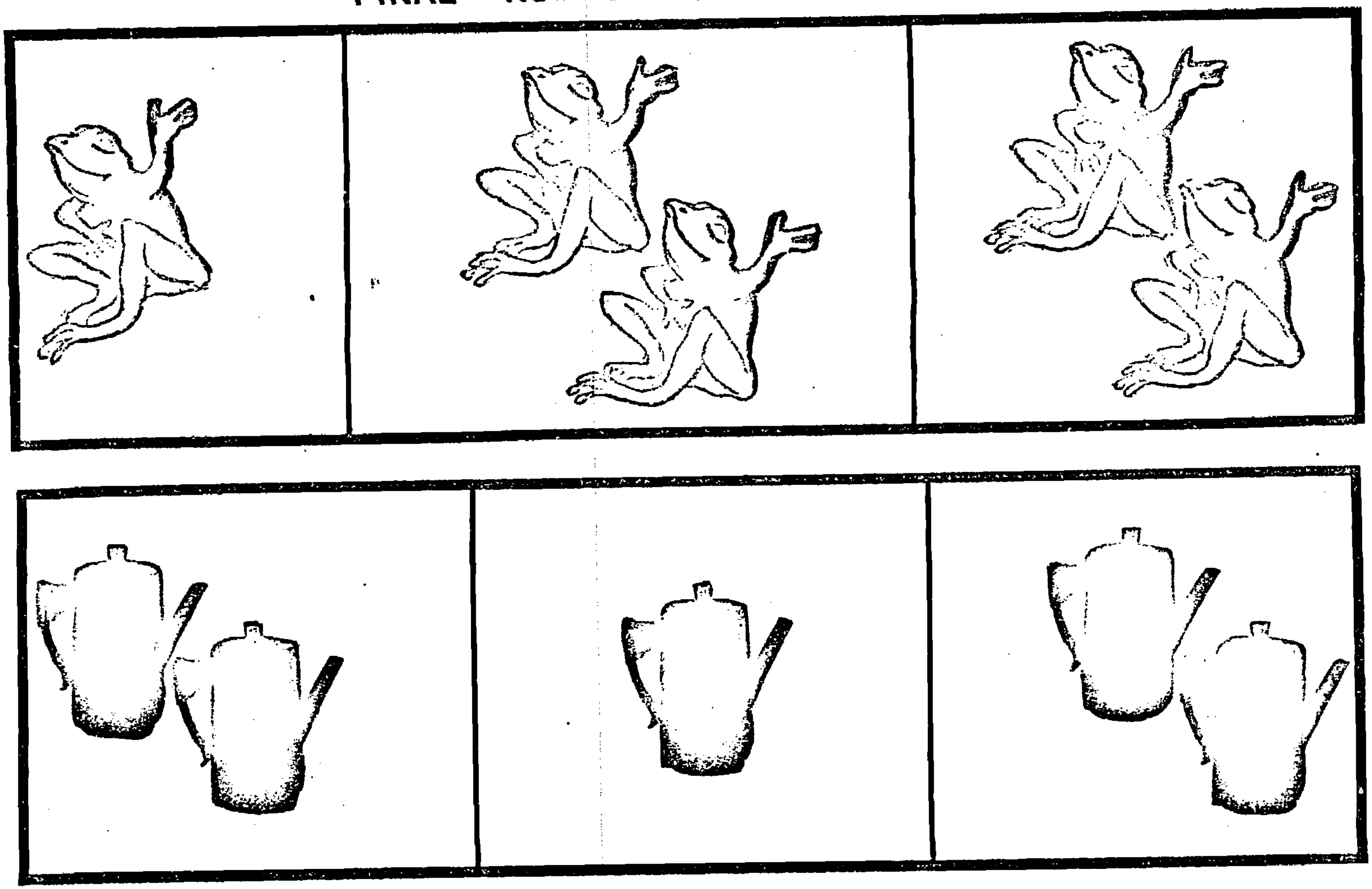

Figure 8. Number oddity display used which resulted in 100% of the children learning.

is certain that the transfer problem will be displaying the number problem in a most advantageous light. If children learning a standard oddity problem have noticed the numerical aspect of the odd picture, then they should transfer to this numerical presentation. An absence of transfer would make it very unlikely that any such cue was being utilized in standard oddity problem solution.

Summary

Although experiments concerned with a numerical oddity display were not proposed in the application, they are in keeping with the general question of conceptual acquisition and transfer. It was shown that four-year-olds are well able to learn a conceptual problem where the identities and differences are defined in terms of numerical groupings. Although the particular numerical display used is rather restricted (two vs. two vs. one) the particular display was determined by the relationship to a standard oddity problem. The original question concerned the numerical differences in a standard oddity problem (two of these--one of these) and whether or not they were perceived as well as the perceptual differences. Thus a transfer task having the same numerical characteristics (two vs. one) was necessary. The two vs. two vs. one display retained the numerical differences as well as the three object (groupings) characteristic.

Further work on a broader numerical relational problem (its the different numerical grouping regardless of the particular numerical instances used -- e.g. three vs. four vs. four; two vs. five vs. two; one vs. seven vs. seven, etc.) is currently being explored. The fact that all the fours learned the simple number problem once the favorable display was determined and learned it easily (few errors and trials to criterion) makes it likely that a large percentage of threes can also learn this simple presentation. If that proves to be true, then this problem may serve as the basic one to get them on the appropriate relational concept and transfer to more complicated numerical displays, as well as possibly using that as a problem to go before a standard oddity display. It is possible that such might enable a larger number of children to get on to the standard oddity problem and then other related oddity problems could be presented following this (study in progress).

Should initial transfer from the simple number problem to the more truly oddity number problem described above not be evident, then transfer sets will be devised to see what cue that single picture has taken on for the children. That is have they learned to select the single instance only, or the smaller value or perhaps some more complicated solution like the one that there aren't two of.

It would seem like a number of interesting studies concerned with the acquisition of and the inter-problem transfer between perceptual and numerical oddity will come out of these initial experiments. Certainly they all will employ several age ranges wherever expectancies for learning are such as to encourage their inclusion. Meaningful transfer studies require initial learning.

Summary of Experiments

The performance of preschool children on several oddity tasks was examined in an effort to better understand the relationship between chronological age and both acquisition and transfer on these relational problems. It was difficult to obtain strong evidence relating age differences to performance differences on transfer, due to the high failure rate associated with the original learning of several oddity types. However, there was some indication that the large age differences present on the original learning task were eliminated or drastically reduced on oddity transfer as long as the changes instituted on the transfer task were not large. When several changes were made (presentation and relevant stimulus dimension) some difference between three- and four-year-old children seemed to remain.

Performance on two oddity variations, which presented perceptual and character overlap between the identical and different pictures, or which relied on character identity alone to form the basis of the matching pictures, was inferior to that found when the odd picture was completely different from an identical pair of pictures. Again a differential failure rate made interpretation of the transfer data difficult, but it appeared that there was a high level of transfer from all three oddity presentations to the standard presentation and the variation with two identical and one similar picture. Transfer to the third variation was not found in this study but was obtained on a subsequent follow up.

A final series of experiments was run with nursery school children investigating the possible perception of both the perceptual and numerical differences present in a standard oddity task as well as the variables controlling initial acquisition of a numerical difference problem. The elimination of perceptual differences was found to be necessary before perception of a numerical difference was obtained. Transfer from a standard oddity problem, where numerical differences are one of the possible differences that can be used to solve the problem (i.e. two of them and one of the other), to a numerical display where a numerical difference is the sole solution, is currently being run. The transfer display is one found to maximize the perception of the numerical differences.

The data from these studies would indicate considerable cognitive evaluation is possible in preschool children. The maintenance and changes in rules or concepts learned in one situation to fit the perceptual displays of subsequent presentations is well within the potential of children younger than five. Additional training strategies are being studied to try and enlarge the transfer capabilities of these three- and four-year-old children in an effort to maximize their bredth of performance so as to get a clearer picture of their developing cognitive control.

Articles Contemplated

1. Transfer of an oddity solution between dimensions and method of presentation by nursery school children.

2. Childrens detection of perceptual and numerical groupings in terms of identities and differences: Some initial findings.